Dr. Croker King made the following communication on the adjustment of the chordæ vocales by the oblique arytenoid muscles:

"In the course of the following communication, it will appear that a peculiar position of the vocal cords is necessary for the production of a distinct intonation; and that, if the vocal cords be not brought into this favourable position, the larynx will cease to execute its function as an organ of voice.

"The means by which this essential adjustment is effected has been a matter of uncertainty and doubt; and the object of this communication is to show that there exists in the human larynx an apparatus of great efficiency, which is capable of executing the desired movement with accuracy and precision; and that, although the muscular fibres which perform this office have been well known to anatomists and physiologists, this special use has not hitherto been assigned to them.

"The term *larynx* has been applied by anatomists to a cylindrical box, which surmounts the trachea or windpipe, and contains the organ of voice. The box is formed of a resisting material, so that its capacity may not be diminished or obliterated by the collapse or falling in of the sides, which, were its parietes formed of a flaccid material, would inevitably result from an effort of inspiration. The animal structure used is named cartilage, and there are several distinct pieces of this material in the larynx; they are connected to each other so as to form articulations or joints, and, appropriate muscles being assigned to them, they can be freely moved upon each other.

"It is not my intention to occupy the time of the Academy by entering into a detailed description either of the laryngeal cartilages or muscles, but to confine myself to such notice of the anatomical features of the larynx as is absolutely required to render the particular object of this communication intelligible.

"The trachea or windpipe is surrounded by a strong ring of cartilage termed the cricoid, which serves as a foundation upon which the superjacent mechanism is erected. Upon the upper

and posterior margin of this cartilage are seated two small solid triangular bodies, named the arytenoid cartilages, and the entire is embraced and protected in front and on the sides by a large shield-shaped cartilage, the thyroid; in this manner the skeleton of the larynx is constructed.

" The base of each arytenoid is concave and of a triangular figure, with two of the angles (the anterior and external) so prolonged as to represent two little processes, which we shall designate spurs; the external spur receives the insertion of two muscles, and from the anterior spur of each cartilage there passes forwards a remarkable cord, which attaches itself in front to the thyroid cartilage. The cords are highly elastic, and it is the varied tension and vibrations of these, the vocal cords, which produce the several intonations that admit subsequently of being fashioned into those articulate sounds of which language is formed.

" The interval between the vocal cords and the inner margins of the base of the arytenoid cartilages is named the rima or chink of the glottis, which in a state of repose (none of the laryngeal muscles being in action) is of the form of the head of an ancient halbert; and *mark*, while in this position, the surfaces of the cords are inclined *from* each other, and the cords are in a state of relaxation. A column of air, though even propelled with force through the rima, under these circumstances, does not produce any distinct sound. For the production of an intonation, two conditions are required, namely, that a certain amount of tension be communicated to the vocal cords, and, above all, that the surfaces of the vibrating material be inclined towards each other, or, at all events, that their planes should become parallel to the axis of the column of air ascending through the tube; for the slightest inclination of the surfaces from this axis completely prevents any sonorous vibration from being produced. In order to illustrate this fact I have arranged a rough experiment. Here are two tubes closed at one extremity, with the

exception of a narrow slit; projecting beyond this extremity of each of the tubes are two pieces of wood, so fashioned that when this piece of elastic membrane is stretched across the extremity of one tube, the surfaces of the membrane will diverge slightly, while, if the same membrane be extended across the other, the surfaces will be parallel, or a little convergent. A column of air, as you may perceive, propelled through the former tube, will only produce a rustling noise, but in the case of the latter a distinct intonation will result.

" It has been already stated that the manner in which this adjustment of the vocal cords, so necessary for the production of a sonorous vibration, is effected, has been a matter of controversy and of doubt; the most generally received opinion being that it is accomplished by means of the thyro-arytenoid muscles; these latter are attached to the thyroid cartilage in front, and to the arytenoid behind. Now, without analysing the action of these muscles, in order to ascertain how far their contractions could influence the parallel condition of the cords, it may, however, be stated, that inasmuch as the muscles and cords are attached to the same cartilages, the action of the muscles will approximate the cartilages, and consequently relax the vocal cords, a condition incompatible with the production of high notes; so that, even supposing these muscles to be capable of effecting the necessary adjustment when a deep note is produced, they could not be used in the production of a high intonation, a certain amount of tension of the vocal cords being, under these circumstances, required. The thyro-arytenoid is a most important muscle of the larynx; it can, in a marked degree, influence the condition of the vocal cords, and is, no doubt, called into action every moment, in regulating the varied and constantly changing tension of the vocal cords; but that it is capable of producing the required parallel position of the cords cannot, we consider, be maintained; besides, it would constitute an anatomical eccentricity that a motion so essential to the function of the larynx that the

mere suspension or interruption of it would be attended with total loss of voice,—it would appear, at least, very unlikely that this motion should not have a special mechanical arrangement constructed for its performance, but that this important office should be delegated to a muscle having a variety of other functions to fulfil.

" The vocal cords are attached, as was before stated, to the thyroid cartilage in front, to the anterior spur of the arytenoid behind; but the arytenoid being smaller and by far more moveable than the thyroid cartilage, a correct knowledge of the motions which can be communicated to the arytenoid cartilages by the laryngeal muscles must be first obtained, before we can estimate the various conditions of the vocal cords.

" The principal motions which are enjoyed by the arytenoid cartilages are the following :—they can be drawn forward, backward, rotated on their vertical axis, or they can revolve on a horizontal axis corresponding to the direction of the anterior spurs. The effects produced on the vocal cords by these motions will be as follows :—the forward motion will relax, and the backward movement will stretch the vocal cords; the rotation in a direction outwards on the vertical axes will separate, and the rotation inwards will approximate the vocal cords; the rotation on the horizontal axes inwards and outwards will cause the anterior spur to revolve, and to carry with it the vocal cord, which will thus alternately incline towards and from the cord of the opposite side.

" In consequence of the articular surfaces in the cricoid cartilage, for the accommodation of the arytenoid, being formed more on the external than the internal surface of the cartilage, the arytenoid cartilages are not seated in an erect position; the axes of the cartilages are consequently divergent, so that the apices are separated from each other above by a considerable interval; and in this state, which is that of repose of the organ, the planes of the vocal cords also diverge from each

other. Now, the parallel position of the cords to a column of air ascending through the trachea admits of being restored by a rotation inwards of the arytenoid cartilages on their horizontal axes, which motion will cause the outer spur of the arytenoid to describe an arc of a circle in a direction upwards, and the apex to describe a similar motion in a direction inwards. We shall now proceed to examine the apparatus which we conceive to be capable of effecting this movement.

"The concave posterior surfaces of the arytenoid cartilages are occupied in the recent state by a muscle called the arytenoid; the fibres of this muscle pass transversely from the outer edge of one cartilage to a similar position on the opposite, and the action of the muscle is to approximate the posterior internal margins of the arytenoid cartilages, and to separate the anterior spurs; or, in other words, to rotate the arytenoid cartilages on their vertical axes in a direction outwards. But, in addition to these fibres, there are others which are usually denominated the oblique arytenoid muscles; it is to these latter that I wish *to direct your especial attention.* The arrangement of these muscular bands is as follows:—one set of fibres passes from the *apex* of the right cartilage to the *extreme* outer *angle* of the base of the left, and another band of fibres passes in a similar manner from the apex of the left to the base of the right; the two bands of fibres forming a crucial intersection on the posterior surfaces of the arytenoid cartilages. The oblique arytenoid muscles, being thrown into action, produce a rotation of the arytenoid cartilages on their horizontal axes; their apices are drawn inwards and approximated, while the outer margin of the base of each is at the same time elevated, and the anterior spurs consequently undergo a rotation inwards: the vocal cords are thus brought into the desired state of parallelism, and so, by this simple arrangement, the conditions necessary for the production of a sonorous vibration are fulfilled.

"It should be observed, however, that although the ob-

lique arytenoid muscles appear to be the *principal*, they are not the *sole* agents in producing the desired adjustment of the cords. The thyro-arytenoid, under certain circumstances, may assist, and also the crico-arytenoid lateralis, as well as the superior fibres of the transverse arytenoid muscle.

" The general form of lever used in the human body is a lever of the third order, with the muscular insertion so close to the fulcrum, that power is altogether sacrificed to velocity; but in the instance of the rotation of the arytenoid cartilage upon its horizontal axis, a bent lever of the first order is used, in which there is a great augmentation of power. The extremity of the vertical arm of the lever is at the apex, and of the horizontal arm at the outer angle of the base of the cartilage; but those two points correspond precisely to the attachments of the oblique arytenoid muscles; and it may be further stated that the incidence of the muscles on the cartilages is most favourable, so that in this particular instance there is scarcely any loss of muscular power. And lastly, it may be observed, that if we do not assign to the oblique arytenoid muscles the special use which we have now delegated to them, they do not appear capable of producing any other motion that could not have been equally well, or indeed more efficiently performed, by the transverse arytenoid muscles."

The following letter from Sir William R. Hamilton was read, giving some general expressions of theorems relating to surfaces, obtained by his method of quaternions:

" The equation of a curved surface being put under the form

$$f(\rho) = \text{const.}:$$

while its *tangent plane* may be represented by the equation,

$$df(\rho) = 0,$$

or

$$\mathrm{S} \cdot \nu d\rho = 0,$$